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Forecasting Corporate Green Investment Bonds – An Out of Sample Approach

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Abstract: Growing corporate awareness and advocacy for ethical finance and production and services has led to growth in green finance and green bonds, but research dealing on forecasting green bonds is scarce. The objective of this paper is to present a global analysis of in-sample and out of sample forecast of global corporate green investment bonds. The Prior work foundation of this paper is inclined on the fusion of modern portfolio theory with sustainable investment. Similarly, global climate vision 2050 highlights the necessity of forecasting global green investment bond availability. Green investment bond data were collected from the S&P Green Bonds Index and the Gretl econometrics and statistics software were used to conduct in-sample and out-of-sample forecast of green bonds. The results show that the in-sample forecast of green bonds provided a good approximation of actual green bonds at a low error rate of 1.3%. in the same vein, the out-of-sample forecast had a very low standard error of less than 1.5% and the forecast trend line lye within the 95% confidence error bars. It provides future information for investors' green bond hedging; provides insight for climate policy advocates on the future of green finance to help plan climate adaptation and mitigation and useful for European countries who carry the burden of climate mitigation fund to developing countries. Future research should apply this method in other sustainable finance research**.** This paper provides the first analysis of green bonds' in-sample and out of sample forecast using the S&P green bonds index; it thus provides information that bridges research gap and that bridges future green bond uncertainty.

Keywords: Capital market; forecasting; green bonds; green stock; environmental investment; out-of-sample forecast

JEL Classification: C53; O16; Q5; 24; B26; M41

1. Introduction

The global awareness for sustainable economic development has attracted growth of investors who demand financial investments that satisfy economic and environmental needs (Pham, 2016). This paper presents an analysis of in-sample and out of sample forecast analysis of global corporate green investment bonds to reduce information uncertainty regarding green finance or green bond availability for corporate green investment planning and decisions. Green investment bonds is a viable capital portfolio to encourage pragmatic participation of the corporate and other private sector stakeholders to provide enabling capital for climate change adaptation and mitigation (Reichelt, 2010). Since the emergence of green bonds in 2007, the green bond market has grown rapidly at an increasing rate. For instance, the stock market issue of green bonds increased from USD11 billion in 2013 to over USD36

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billion in 2014 (Pham, 2016). Accordingly, the continual expansion of green bond markets around the world makes it important to provide green investors and policy makers with a future forecast of likely green bond availability. This forecast is currently absent in the literature, hence the novelty and contribution of this paper. Green bonds represent one of the aspects of fixed income investment portfolio, which are very attractive to investors seeking both financial gain albeit remaining sustainable investors. Hence green investment bonds leads the way amongst the financial instruments that provide financial capital for enhancing sustainable economic development (Reichelt, 2010).

Feylo (2012) argues that conventional models and/or techniques of investment analysis have largely paid little attention to the growing green investment environment; what is currently visible in regards to this is more of risk and return analysis to assist with investment decision about environmental investment. Therefore, Felo (2012) suggests that developing and applying green investment analytics and techniques will provide enabling information to green investors and fund managers (Feylo, 2012).Therefore this paper provides an initial attempt in using the in-sample forecasting approach to approximate the out-of-sample forecasting of green investment bonds using the S&P green investment bonds index. Hence this paper contributes to knowledge by using the green bonds to conduct and in-sample and out-of-sample forecast of green investment bonds.

2. The Problem

The problem of this paper is that despite the growing recognition that green bonds are vital for tackling green investments targets for vision 2050, there is paucity of research on forecasting green bonds. The closest research (although still detached from this focus) are on green trade forecasting (Sheng 2007); analysis of green bond market volatility (Pham, 2016). However none of the foregoing related research has actually focussed on forecasting of green bonds. Yet there is increasing demand for green bonds by green investors (Ehlers & Packer, 2017), these investors may need the forecast information to reduce green bond availability uncertainty. Therefore, this paper makes new contribution to the literature by bridging this existing gap in the literature and used the S&P Dow Jones Green Bond Index to embark on an in-sample and out of sample forecast of green bonds. This contribution is significant given that the data used is from S&P Dow Jones, which provides green bond indices covering global green markets.

2.1. Objective of Paper

Drawing from the preceding introduction and problem statement, the objective of this paper is to use the Gretl software to estimate the in-sample forecast of green investment bonds and thereafter, relying on the value of the in-sample forecast, proceeds to conduct the out-of-sample forecast of green investment bonds using the S&P green investment bonds. The aim thus is to provide an out-of sample forecast of green investment bonds that can reduce future green bond investment uncertainty to investors.

3. Literature Review

The theoretical underpinning of this paper is rooted in the emerging fusion of modern portfolio theory with green or sustainable investment considerations given the bourgeoning of green and socially responsible investors. Hence this paper draws a theoretical underpinning from Peylo (2012) research which advocate integrating investment portfolio theory with green investment. Accordingly, Feylo (2012) opines that given growing advocacy for environmental and green responsibility, current corporate strategy will do better if there is a synthesis amongst conventional economic objective and environmental objectives. This means that companies with green related products and production processes are becoming attractive to green investors who target financial reward and environmental ethics (Feylo, 2012). However, conventional models and/or techniques of investment analysis have largely neglected the growing green investment – at best what is common is risk and return analysis to improve investment planning and decision. Hence, Felo (2012) recommends that accommodating green investment in analytical and modelling techniques to provide enabling information to green investors and fund managers (Feylo, 2012).

The global resource efficiency target is enshrined in climate vision 2050 (Schanes, Jager & Drummond, 2019). This global sustainability ambition highlights the importance of forecasting green bond availability as green finance is the fundamental tool for achieving target resource efficiency for sustainable economic development target in 2050 (European Commission, 2016). Hence economics and finance constitute an important arm of global advocacy for a sustainable future by broadening the stock exchange markets around the world to improve green finance availability through green bonds (Ng, 2018; Schafer, 2018).

But there is scanty research and literature around the subject of forecasting green bonds (Sheng, 2007); however, closely related literature revolve around green investment trends and others around forecasting stock market volatility (Lin, 2018; Pati, Barai & Rajib, 2018; Shen, 2007; Kin & Cho, 2014; Porfir'ev, 2016). The literature highlights that green bonds or green stocks are part of normal stock markets (S&P, 2019). It is thus estimated that up to one trillion US Dollars is needed per year to achieve sustainable investment needs for greening the environment, hence the importance of developing new stock markets to service desired green investments (Mathews & Kidney, 2012). Researchers have sought to measure the determinants of green bond supply, for instance, Chiesa and Barua (2019) examined the determinants and magnitude in the supply of green bond and the attendant heterogeneity in various markets. They used the Bloomberg corporate data for green bonds issue for 2010 to 2017 and examined the features, which impact the size of green bonds borrowing. Chiesa & Barua, 2019) employed a tri-dimensional features, namely the market dimension, issuer dimension and security dimension to examine the uniformity of the impacts across emerging markets and other markets. Findings from their analysis indicate that, generally, the bond issue size has a positive relationship with the collateral availability, credit rating and sector financial health. They also find that green bond issues from emerging markets perform better in terms of reliability and enhance returns if they have international affiliations such as EURO denominated. They recommend increased supply of green bonds through impact borrowing policies as incentives (Chiesa & Barua, 2019).

Li et al (2019) applied regression analysis to study the interest cost and the effect of credit ratings along with green certification on the yield spread of green bonds with data from Chinese green bonds. They find that credit ratings and green certification pose a significant impact on green bonds' interest costs. They also indicate that green bonds that have green certification attachments attract lower interest rates better than green bonds without green certificates. Hence, ability to issue green bonds is a good test of business social and environmental responsibility (Li et al, 2019). Pham (2016) analysed the volatility of green bond market by using daily price data from the S&P green bond indices for April 2010 to April 2015. He applied GARCH multivariate model and found that the labelled section of the green bond market show large volatility pattern, however ever, this volatility is less pronounced in the unlabelled sector of the green bond market. His research also revealed that the volatility shock in the conventional stock market exhibit a spill-over and variable effect into the green bond market. Hence Pham (2016) findings have practical implications for portfolio risk management for green bond and conventional stock markets. Reboredo (2018) analysed the co-movement between the financial and green bond market and found that green bonds exhibit and weak co-movement with the stock market and that price oscillations in conventional stock markets constitute insignificant effect on green bond prices. They also found that green bond diversifications have diverse impact on corporate and stock investors. Whereas green bond diversification have attract ample benefits for stock market investors, such diversification has trifling effect for corporate investors (Reboredo, 2018). Recently, other researchers have sought to measure the correlation types which exist between green bonds and black bond markets; they apply sequential dynamic conditional and dynamic averaging correlation technique and found that the correlation between green bonds and black bond market is sensitive to volatility changes in financial market, economic policy uncertainty and sentimental good and bad news regarding green bonds (Broadstock & Cheng, 2019). The price relationship between green bond market and financial market was examined by Reboredo & Ugolini (2019); they applied the vector autoregressive model and found that the green bond market is related to the currency and fixed-income markets. They also found that price spill over from these markets affect the green bond market but lacks a reverse effect from the bond market.

4. Method

Data for 255 days covering January 07 2019 to December 27 2019 were collected from the S&P Green Investment Bonds Index and saved into excel spread sheet from where it was loaded into the econometrics and statistics software. The green bonds data had no name when uploaded to GRETL software, so GRETL gave it automatic name, which is V1, but to give it a proper name. Data were examined for strong or soft seasonality, if the spikes are long, it can be interpreted as strong seasonality but short spikes indicates none or weak seasonality. Note that a non-seasonal bond with growth trend such as in Figure-1 is more reliable than many other stocks and bonds with strong seasonality albeit high growth trend. In order to regress green bonds against time periods, time trend variable were added to the loaded data in the Gretl software. In addition, periodic dummies were added to the loaded data. The following section discusses the results.

4.1. Results

The time series plot shows an upward trend in green investment bonds; the short spikes shows that the green bonds are without strong seasonality, which is an indication that green bonds are comparatively a reliable investment unlike many other product’s bonds.

From the linear regression output in Table, it can be seen that only the time trend is statistically significant at less than 0.001, which is well less than alpha value of 0.05. An in-sample forecast is shown in Table 2, which excludes the last day of the year result in Table 2 shows a good quality of the forecast, which indicates an absolute mean percentage error of less than 1% deviation, which is a good indicator that the in-sample forecast is close to the actual green bond data for December 27 2019. This is also an indicator of the fact that one can rely on the ensuing out of sample forecast.

To assess the quality of in-sample forecast, the mean absolute percentage error is the indicator of quality of variation from the actual. Normally the deviation is deemed good if the mean absolute percentage error is not more than 10%. Furthermore, Figure-2 indicates that the actual green bonds for the month of December 2019 falls within the range of 95% confidence internal error bars, which indicates that the actual green bonds are close to the forecasts. This gives a measure of trust on the ensuing out of sample green bonds forecast for the twenty days in the month of January 2020. Hence, Figure 3 shows that the forecast is lying inside the 95% confidence error bars; since there is not actual green bond performance to compare the forecast green bond performance for January 2020, a confidence is drawn from the last one month in-sample forecast done for the month of December 2019 and the fact that the forecast for January 2020 lies inside the 95% confidence error bars.

The OLS regression model in Table 1 indicates that time is significantly and positively related to the performance of green bonds at a p-value of less than 0.001 with a positive regression coefficient of 0.03, which suggests that the passage of time, yields enhanced performance to the green bonds. This is confirmed by the high adjusted R-Squared of over 0.76%. This is not surprising given that the passage of time brings increased awareness of environmental investment to investors and consumers.

Investors need to have an approximation knowledge of future stock performance, the recent and sustainability important nature of green stocks or green bonds makes it more imperative for green bond investors to have knowledge of future green bond performance so the investors can make advanced decision. The in-sample forecast result in Table 2, Table 3 and Figure-2 provides good information for green investors to rely on and this provides a measure of trust on futuristic out-of-sample green bond forecast. This is because an index of in-sample forecast performance evaluation, which is the 'mean absolute percentage error' is only 1.31 – which indicates that the green bond forecast deviation from the actual is only 1.31. Since expert suggestion indicates an acceptable deviation percentage of about 10% as an excellent result and 20% as a good result (Gilliland, 2010), this shows that the current result of 1.31% provides a measure of trust on the ensuing out-of-sample forecast result in Table 4 and Figure 3. In addition, the standard errors are all less than 1.5 percent which is low and shows that the predictions fall close the actual. An upward growth trend can be seen in Figure-2 (in-sample forecast); the same upward trend is visible in Figure (out of sample forecast). Furthermore, the out-of-sample forecast is presented in Table 4 and Figure 3.

The actual green bonds for January 2020 are undefined because in the data used, it is meant to be futuristic (unknown), but the forecast is shown in column three of Table 4, similar to the in-sample forecast, it can be seen that that all the standard errors are less 1.5%, which indicates low standard error, showing that the forecast provide reliable approximation of green bonds performance during the period of forecast. Since the out-of-sample standard errors mimic the in-sample standard errors, this shows that the in-sample forecast provides a good trust that using the same data to conduct an out-of-sample approach would yield a good approximation.

Figure 3 shows upward trend of green bond forecast and the trend line lye inside the 95% confidence error bars – which is an indication that forecast provides good approximation of green bonds to investors. This therefore implies that green investors, stock analysts and investors can make use of in-sample forecast to increase understanding of the performance of out-of-sample forecast in providing additional green bond investment information to enhance early green bond investment decisions.

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Figure 1. S&P Green Bonds Time Series Plot (Jan 07 to Dec 27 2019)

Table 1. Model 1. OLS, using observations 2019/01/07-2019/12/27 (T = 255) Dependent variable: GreenBonds

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	135,314	0,217983	620,7534	<0,00001	***
time	0,030473	0,00105171	28,9748	<0,00001	***
dummy_2	-0,0208652	0,244774	-0,0852	0,93214	
dummy_3	0,0570932	0,24478	0,2332	0,81576	
dummy_4	0,0248555	0,244792	0,1015	0,91921	
dummy_5	0,0361472	0,244808	0,1477	0,88273	

Mean dependent var	139,2339	S.D. dependent var	2,559592
Sum squared resid	380,4179	S.E. of regression	1,236035
R-squared	0,771395	Adjusted R-squared	0,766804
F(5, 249)	168,0430	P-value(F)	1,16e-77
Log-likelihood	-412,8302	Akaike criterion	837,6604
Schwarz criterion	858,9080	Hannan-Quinn	846,2070
rho	0,974378	Durbin-Watson	0,052762

Table 2. In-sample Forecast (20 Working Days) for the Month of December 2019 For 95% Confidence Intervals, t(229, 0,025) = 1,970

Obs	GreenBonds	prediction	std. error	95% interval
2019/12/02	140,910	143,009	1,21840	(140,608, 145,410)
2019/12/03	141,510	142,997	1,21840	(140,596, 145,398)
2019/12/04	141,340	143,123	1,21840	(140,722, 145,523)
2019/12/05	141,300	143,124	1,21840	(140,723, 145,524)
2019/12/06	140,950	143,157	1,21840	(140,756, 145,558)
2019/12/09	141,170	143,177	1,21907	(140,775, 145,579)
2019/12/10	141,310	143,165	1,21907	(140,763, 145,567)
2019/12/11	141,560	143,291	1,21907	(140,889, 145,693)
2019/12/12	141,460	143,292	1,21907	(140,890, 145,694)
2019/12/13	141,970	143,325	1,21907	(140,923, 145,727)
2019/12/16	141,870	143,346	1,21976	(140,942, 145,749)
2019/12/17	142,040	143,334	1,21976	(140,930, 145,737)
2019/12/18	141,580	143,459	1,21976	(141,056, 145,863)
2019/12/19	141,460	143,460	1,21976	(141,057, 145,864)
2019/12/20	141,340	143,493	1,21976	(141,090, 145,897)
2019/12/23	141,250	143,514	1,22049	(141,109, 145,919)
2019/12/24	141,390	143,502	1,22049	(141,097, 145,907)
2019/12/25	141,400	143,627	1,22049	(141,223, 146,032)
2019/12/26	141,520	143,628	1,22049	(141,224, 146,033)
2019/12/27	142,050	143,662	1,22049	(141,257, 146,067)

Table 3. In-Sample Forecast Evaluation Statistics

Mean Error	-1.8653
Mean Squared Error	3.5631
Root Mean Squared Error	1.8876
Mean Absolute Error	1.8653
Mean Percentage Error	-1.3189
Mean Absolute Percentage Error	1.3189
Theil's U	6.6398
Bias proportion UM	0.97647
Regression proportion UR	0.0013515
Disturbance proportion UD	0.02218

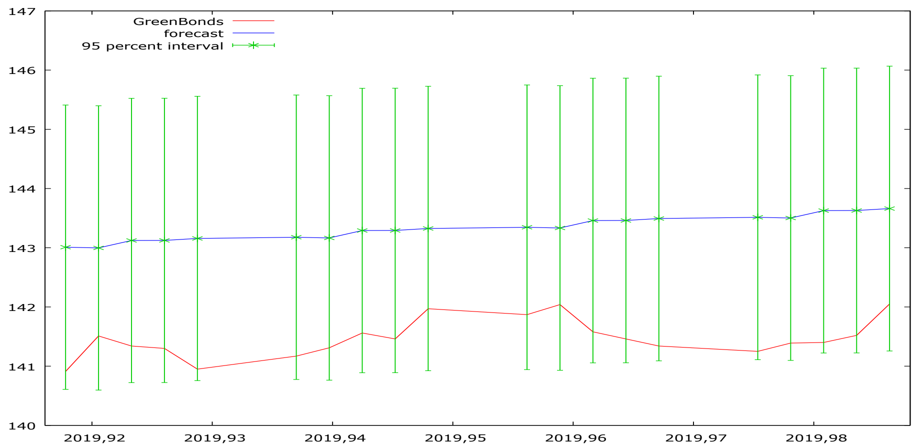

Figure 2. In-sample Forecast (20 working Days) Plot for the Month of December 2019

Table 4. Out-of-sample Forecast (20 working Days) for the Month of January 24 2019 For 95% confidence intervals, t(249, 0,025) = 1,970

Obs	GreenBonds	prediction	std. error	95% interval
2019/12/30	undefined	143,115	1,25556	(140,642, 145,588)
2019/12/31	undefined	143,125	1,25556	(140,652, 145,598)
2020/01/01	undefined	143,233	1,25556	(140,760, 145,706)
2020/01/02	undefined	143,231	1,25556	(140,758, 145,704)
2020/01/03	undefined	143,273	1,25556	(140,800, 145,746)
2020/01/06	undefined	143,267	1,25614	(140,793, 145,741)
2020/01/07	undefined	143,277	1,25614	(140,803, 145,751)
2020/01/08	undefined	143,385	1,25614	(140,911, 145,859)
2020/01/09	undefined	143,384	1,25614	(140,910, 145,858)
2020/01/10	undefined	143,425	1,25614	(140,951, 145,899)
2020/01/13	undefined	143,420	1,25675	(140,945, 145,895)
2020/01/14	undefined	143,429	1,25675	(140,954, 145,905)
2020/01/15	undefined	143,538	1,25675	(141,063, 146,013)
2020/01/16	undefined	143,536	1,25675	(141,061, 146,011)
2020/01/17	undefined	143,578	1,25675	(141,103, 146,053)
2020/01/20	undefined	143,572	1,25738	(141,096, 146,049)
2020/01/21	undefined	143,582	1,25738	(141,105, 146,058)
2020/01/22	undefined	143,690	1,25738	(141,214, 146,167)
2020/01/23	undefined	143,688	1,25738	(141,212, 146,165)
2020/01/24	undefined	143,730	1,25738	(141,254, 146,207)

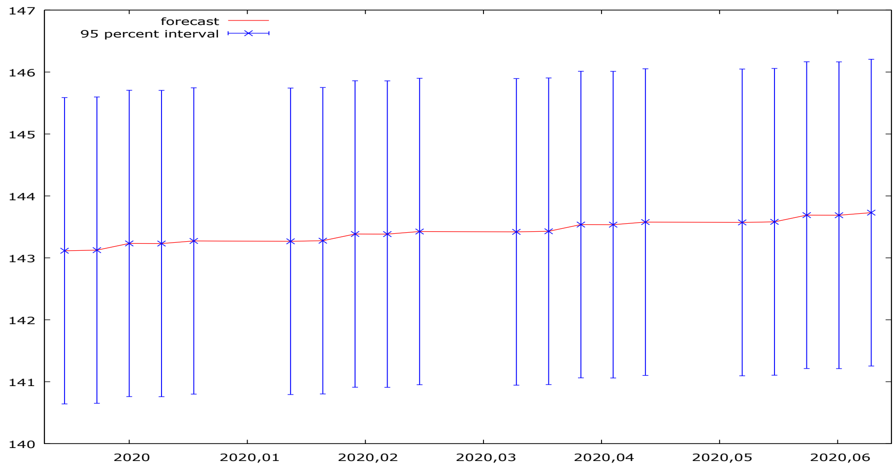

Figure 3. Out of Sample Forecast Plot for January 2020

4.2. Implication for Policy, Investors and Research

Given the increasing demand by green investors, policy makers may encourage increased green bond issues by devising an incentive strategy to elicit more green bonds into the stock market of emerging countries. Furthermore, the findings of this research provide practical insight for green bond portfolio risk management for green bond investors and issuers. Further research is recommended to employ increased time series in forecasting future green bonds in the S&P Dow Jones and in other markets by extending the forecast time into the future to see how the in-sample forecast can approximate the out-of-sample forecast. Overall, the out-sample forecast provides additional information for green bond investors.

4.3. Value (Contribution of Paper)

This paper provides original contribution to the literature given that no existing research has not as yet engaged in this new area of forecasting green bonds, especially the S&P green bonds. This is the first research paper, which provides future green bond performance forecast for S&P green bond investors, which thus reduces green bond investment information uncertainty. In addition, this is the first paper that has used the S&P Dow Jones Green Bond Indices in performing in-sample and out-of-sample forecast of future green bonds with the application of Gretl Econometrics and Statistics software.

5. Conclusion

This paper set out to examine how the usage of in-sample forecast can provide good result in order to performance further out-of-sample forecasting of green investment bonds to provide additional information for green investors. Results show that the analysis using the sample of green bonds from the S&P green bonds provides good in-sample forecasts since the mean absolute error is way below 10%. Furthermore, the out-sample forecast yielded a good forecast result since the standard error for all the forecast was below 1.5% and the out-of-sample forecast trend line lye inside the 95% error bars. Therefore this analysis of forecasting green bonds provides investors with a tool of forecasting to enhance green investment decisions regarding future investment in green bonds when the market is yet uncertain. This results shows that at least, the green bond investors can rely on one month forecast ahead to make green bond investment decisions. Further research is required to extend the forecast to many more months in the future to provide extended future reliance on forecasts to make green bonds investment decisions. The practical implication is that green investors, stock analysts and investors can make use of in-sample forecast to increase understanding of the performance of out-of-sample forecast in providing additional green bond investment information to enhance early green bond investment decisions. This approach can also be applied in forecasting equity stocks.

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